and contain a nucleus half as wide as themselves, which is more granular, and which contains a distinct, highly refractive, spherical, structureless-looking nucleolus about one-third to one-fourth as wide as the nucleus itself. Notwithstanding the size of the sperms, a fertilized female may contain hundreds of them. The matured ova are rather coarsely granular, are pressed one against another in the ovary and sometimes appear wider than they are long, and in some parts apparently are packed more densely than double file. *At the vulva the body of the female suddenly diminishes* in diameter, so that in passing one-half body length caudad the diameter diminishes fifty per cent.

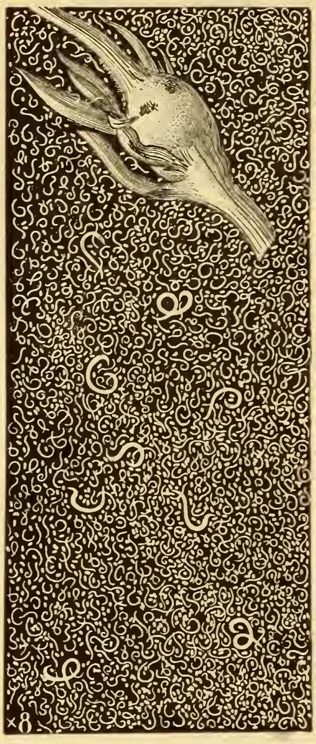

Fig. 2.—A gall from the tissues of the base of a leaf sheath. A portion of the sheath tissue pulled away nearly intact. The inner tissues of the sheath had produced the wall of the tumor. The mushy interior was very distinct from the wall, and occupied a distinct cavity, in which the nemas lay loose, free to move about. The nine adult nemas and the numerous eggs and larvae shown were taken from another gall of *the same size*. Thus the picture shows a gall and a corresponding nemic population.

The transverse striae of the cuticle, measured just behind the vulva, are one micron apart.

The inconspicuous, posterior, bulbous half of the spear, which accords with conditions found in some other species of *Tylenchus*, suggests that published illustrations and descriptions of a considerable number of Tylenchi may ultimately have to be revised for the reason that the more obvious anterior half of the spear has been inadvertently described as if it were the entire organ. Sometimes the posterior portion of the onchium of a Triplonch may, even in life, be very inconspicuous and become nearly invisible when mounted in glycerine or glycerine jelly,—still more so in balsam. Under such deceptive conditions the real length of the spear is sometimes indicated by the length of the contractile fibers passing from the labial framework to the tribulbous base of the spear, as in the present case. See Fig. 3.

0.8	5.3	(?)11.	80 M	94.	1.2 mm
1.1	2.0 /	(?)2.6	3.2	2.6	

The vas deferens and ejaculatory duct occupy the greater portion of the body cavity toward the posterior extremity of the male. The testis is strongly developed and at its *bent blind end* is slightly expanded, measuring there about one-half the corresponding body diameter. At first the primary spermatocytes contain large subspherical nuclei with distinct nucleoli, the nuclei being one-fifth to one-sixth as wide as the corresponding portion of the body.

Habitat: Found in small galls on the above-ground parts of the grass *Cyanodon sp.*?,—presumably *C. transvalensis*. (*Fide* A. S. Hitchcock). The plants are killed by the parasite, the grass dying off in patches. Sent by Dr. Potgetier, from Pretoria, South Africa.

Diagnosis. **Tylenchus tumefaciens** n. sp. *Tylenchus* Bastian, formed and dimensioned as indicated in the formulae, illustrations and italicized text.

This nematosis[3] has recently come to notice in a number of Bradley grass lawns in Johannesburg and Pretoria. It seems probable that it occurs widely. Usually it is first noticed in small patches. A close examination of a diseased plant discloses greenish or reddish lumps up to the size of a canary seed, occurring on the stems and leaves,—less often in the inflorescence. Breaking these tiny galls, one discovers with a magnifying glass that the interior of the gall is inhabited by nemas, the cause of the disease. An infestation of one Pretoria lawn was traced to another lawn, from which some planting grass had been taken.

The tiny galls, or tumors, on the grass are so inconspicuous that they might easily escape notice and the disease be unwittingly spread. Once present, the disease accumulates, and after a year or more, patches of ailing grass become apparent. The pest is believed to have been present in Pretoria for some years. The abandonment of one variety of lawn grass[4] is probably due to this disease.

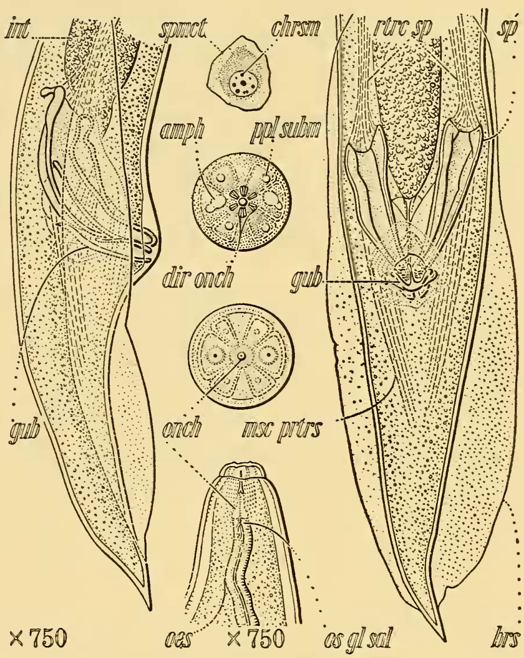

Fig. 3.—Lateral and ventral views of the tail end of the same male specimen of *Tylenchus tumefaciens* n. sp. Below, head of the same, dorsal view. The upper small figure is of a spermatocyte whose nucleus shows chromosomes. Of the two middle figures, the upper is a front view of the head, showing the four submedian papillae and the two duplex amphids, while immediately below is an optical section at the base of the lip region, each magnified about fifteen hundred diameters.

Precautions. 1. Prompt burning off of diseased patches after spraying with inflammable liquid,—i.e. kill the tops, not the roots. 2. Avoidance of seed and cuttings from infested areas. 3. Unusually careful inspection of grass cuttings used as sets. 4. Recleaning of suspected grass seed.

[3] Abstract from *South African Gardening and Country Life* **15**, Jan., 1925.

[4] Variety "Red Quick Grass," presumably a species of *Cyanodon*. N. A. C.

ZOOLOGY.—*The life in the ocean from a biochemical point of view.*[1] PAUL S. GALTSOFF, United States Bureau of Fisheries.

For many years the interest of zoologists engaged in a study of marine life centered around morphological and taxonomic problems. Numerous expeditions organized by every civilized country of the world have collected an enormous amount of zoological and botanical material and have accumulated many data concerning the distribution of animals and plants in relation to the physical and chemical conditions in the sea. Many efforts were made to take a census of the total population of the ocean and to determine its fertility. For that purpose thousands of samples of plankton and of the forms living on the bottom were collected and studied. The reports of these investigations fill thousands of pages and are at present available for further scientific analysis. Unfortunately in many instances when attempts were made to correlate the biological data with physical and chemical observations, the results were conflicting and difficult to interpret. It seems that quite often the broader problems of oceanic biology were buried under the vast material accumulated by the expeditions, and that the scientific research was not in proportion to the effort and money spent.

During the last ten years there has been a revival of interest in oceanographical research in this country, which culminated in the establishment of a number of new institutions for the study of the ocean. The question naturally arises as to what are the outstanding problems in modern oceanography which justify both the expenditure of large sums of money and of human effort. It is quite obvious that the continuation of purely taxonomic and descriptive investigations so extensively carried out since the time of the *Challenger's* expedition will not help in unravelling the complicated relations that exist between the inhabitants of the sea and their environment; neither will they determine the factors that control their propagation and distribution in the ocean.

One of the main results of previous studies was a recognition of the fact that the population of the sea is subject to regular cyclic changes. Certain forms appear during definite seasons, reach the maximum of their abundance, then decline and give place to another group of forms, which pass through a similar cycle. Inasmuch as these changes are

[1] Received February 9, 1932. Third paper in a symposium, *Major problems of modern oceanographic research,* at the meeting of the American Association for the Advancement of Science, at Pasadena, Calif., June 17, 1931.

very pronounced in planktonic forms, like diatoms or dinoflagellates, most of the investigations concerning the periodicity of life cycles refer to these organisms. However, cyclic changes occur also in nektonic and benthonic forms. Many speculative theories were advanced to explain this phenomenon. Real progress was made during the last decade by the investigators of the Plymouth Station (England) who have demonstrated that cyclic changes are accompanied by profound changes in the chemical composition of sea water, and that the decrease or increase in the amount of various salts (phosphates, nitrates, silicates) can be correlated with the abundance or scarcity of various planktonic forms. Thus the morphological and taxonomic investigations in oceanography gradually give place to physiological and biochemical research.

The propagation of organisms in the ocean is dependent on the presence of various elements which are necessary for the building up of their bodies. Lack of a necessary element or its presence in a state not available for a given organism becomes a factor preventing its growth and propagation. Thus, the minimum concentration of any substance indispensable for a given organism becomes a factor limiting the propagation of this particular species. This principle established by Liebig and known as the "law of a minimum" is applicable both to land and marine forms.

There exists a great variety of physical and chemical factors that may interfere with the growth of living forms or check their propagation. On the other hand a temporary absence of limiting factors may result in an extremely rapid propagation of the organism which, in a short time, may fill up all the space available for its growth. Such a phenomenon, quite common in unicellular and planktonic forms, has been very appropriately called by Vernadsky "an explosion of life." It is often observed in fresh water ponds or in enclosed bays. The best example of it in the sea is found in a sudden propagation of a diatom *Aulacodiscus kettoni* along the Copalis beach in the state of Washington, where under certain conditions described by Becking and others[2] it develops in a nearly pure culture. As a result of this rapid development a large amount of phosphates, nitrates, silicates, and other salts, are withdrawn from the sea water, accumulated in the bodies of the diatoms and deposited in a thick layer on the bottom. The process continues for several days, then ceases, to recur again after a

[2] Becking, L. B., Tolman, C. F., McMillin, H. C., Field, J., and Hashimoto, Tadaichi. Economic Geology **22**: 356–368. 1927.

period of inactivity which may last for several weeks. The development of *Aulacodiscus* is a good example of a dynamic equilibrium that exists between the living organism and the surrounding medium. The diatom withdraws from the solution and accumulates in its body several elements that were present in the water, producing considerable change in the chemical composition of the latter which, in turn, becomes a factor limiting its further growth and propagation. There is no doubt that every organism behaves in a similar way differing only in the velocity and type of chemical reactions involved in its activity.

The biochemical rôle of organisms in the ocean can be understood by comparing the chemical composition of sea water with that of the living matter. In this attempt we meet with an unexpected difficulty. Our knowledge of the chemical composition of sea water is very inadequate. Most of the analyses deal with the salts that are found in relatively large concentrations, and neglect the elements occurring in very small amounts. Yet, as it will be shown later, the physiological rôle of the latter may be of great importance, and their presence in the water may be prerequisite for the propagation and development of certain forms. The most complete summary of the present state of our knowledge of the chemical composition of the sea water is given by Vernadsky[3] in Table I.

TABLE I.—The Average Composition of Sea Water (According to W. I. Vernadsky)

Elements	Per cent	Elements	Per cent
O	85.80	Fe	1.5×10^{-4}
H	10.67	Ag	1×10^{-4}
Cl	2.07	P	$n \times 10^{-4}$ ($n \times 10^{-5}$)
Na	1.14	Ar	5×10^{-5}
Mg	1.4×10^{-1}	I	$n \times 10^{-5}$ (n 3)
S	9×10^{-2}	F	3×10^{-5}
Ca	5×10^{-2}	B	$n \times 10^{-5}$
K	4×10^{-2}	Cu	$n \times 10^{-5}$ (n = 1 or 2)
C	3.5×10^{-3}	Li	6×10^{-6} (8×10^{-6})
Br	2×10^{-3}	Au	1.2×10^{-6}
N	1.6×10^{-3}	As	1×10^{-6}
Rb	1.5×10^{-3}	Th	1×10^{-6}
Si	$n \times 10^{-4}$ (n = 3?)	Zn	$n \times 10^{-7}$ (n 1.2?)
		Ra	n 1.4×10^{-12}

[3] Vernadsky, W. Rev. Gen. d. Sc. Pures et Appliques, **35**: 5–13. 1924. *La Geochimie.* 1924. Libr. F. Alcan. Paris.

An examination of Table I shows that our knowledge of the composition of the sea water is far from being complete, and that for a number of elements the quantitative data are only approximate. The table does not contain data for Al, Pb, Ti, Sr, and V which were found in certain marine organisms and probably occur also in sea water. On the other hand, one must bear in mind that the investigations of Atkins, Nathanson, Harvey and others have demonstrated that the concentrations of nitrates, phosphates, and silicates, do not remain constant, but are subject to considerable fluctuations, depending on the activity of the organisms. Thus, the old conception of the constancy of the chemical composition of sea water, established by Forchhammer in 1850–1860, and up to present time generally accepted in oceanographical literature, should be considered with certain reservations. We know that not only does the salinity (i.e. the total amount of salts in solution) vary in different localities, but that there exist considerable fluctuations in the proportion of certain salts. Although the absolute figures may appear insignificant (for instance the phosphate content of the water in the Faeroe-Shetland Channel varies from a few to forty milligrams per cubic meter), they may have a strong effect on the population of the sea.

A comparison between the chemical constituents of the sea water and those of the living matter convinces us that many of the elements that occur in the sea in a highly dispersed state are accumulated in the bodies of the living forms. Unfortunately, whereas the chemical composition of the sea water is not well known, our knowledge of the chemical composition of the living matter is even more fragmentary. According to Vinogradov[4] less than one-half of one percent of all the living species have been subjected to elementary chemical analysis, which in most of the cases dealt with only a few elements. Analyses of the whole body of the organisms are also nearly absent, the chemical data usually referring to the composition of the separate organs, skeleton, or blood.

Excepting the well known work of Bütschli[5] and a general review of Aron[6] the information regarding the chemical composition of various organisms is available mainly from the mineralogical literature and refers almost exclusively to the skeletons and shells. The most impor-

[4] Vinogradov, A. "Priroda" No. 3, pp. 230–254. 1931.

[5] Bütschli, O. Zool. Anz. **30**: 784. 1906. K. Gesell. Wiss. Göttingen, Math-Physik. Kl. **6**, Band 6. 1908.

[6] Aron, H. Oppenheimer Handbuck d. Biochemie, I, p. 62. 1909.

tant contributions are those of Cayeux,[7] Samoilov,[8] Vernadsky and Clarke and Wheeler.[9] These investigations closely connect the problems of marine biology with geology and mineralogy, and stress the rôle of living forms in the origin of various minerals of sedimentary rocks.

A survey of available literature on the subject reveals that the same elements that are found in the sea water occur also in the organisms, although in entirely different concentrations. Some of them as for instance calcium, sulphur, potassium, carbon, nitrogen, silicon, iron, phosphorus, iodine, fluorine, boron, copper, zinc, manganese, vanadium, lead, and titanium are concentrated in the living matter while others, as for example sodium, chlorine, bromine, magnesium, occur in it in concentrations approximately equal to that in the sea water.

TABLE II.—Accumulation of Elements by Living Matter

Elements	Concentration Times
S	100
P	1000
Si	1000
K	10
Fe	100
Zn	10,000
Cu	100
I	100
As	100
B	10
F	10

Vernadsky gives estimates (Table 2) of the minimum concentration of various elements in the bodies of marine forms, as compared with their concentration in the sea water. The figures do not refer to any particular organism but are the averages for the living matter in general.

Although it is known that Al, Mn, Pb, Ti, and V are accumulated by the organisms, it is impossible at present to express their concentrations in definite figures.

Marine plants and animals can be grouped on the basis of the ele-

[7] Cayeux, L. *Introduction à l'étude pétriographique des roches sédimentaires.* Paris. 1916.

[8] Samoilov, J. Mineral. Magazine **18**: 87. 1917. Comp. Rend. d. XIII, Congr. Geolog. Intern. 1924. Centr., of Mineral. 19, 594. 1924.

[9] Clarke, F. W., and Wheeler, W. G. Proc. Nat. Acad. Sc. 1, p. 262. 1915. U. S. Geol. Surv. Prof. Paper 124. 1922.

ments that are accumulated by their bodies. The space of this paper does not permit us to give a complete list of them, and we have to restrict our discussion to a few outstanding examples. We begin with the accumulation of calcium. According to Clarke[10] the annual deposition of calcium in the sea amounts to 1400 million tons. The greatest rôle in the process of withdrawing lime from solution and depositing it on the bottom should be attributed not to the vertebrates, corals, molluscs or other larger organisms with calcareous skeleton, but to the smallest Protozoa belonging to the group of Coccolithophoridae. Their importance in the deposition of calcium was suggested by Lohman,[11] who found that every twenty-four hours one-third of the population of these forms dies and sinks to the bottom, where it takes part in the formation of calcareous deposits.

The skeletons of marine organisms accumulating calcium are built either of calcium carbonate (aragonite and calcite $CaCO_3$; dolomite, $CaCO_3MgCO_3$) or calcium phosphate ($3Ca_3(PO_4)_2CaCO$) and apatite $(CaF)Ca_4P_3O_{12}$. A study of the chemical composition of shells of Brachiopods and Echinoderms by Clarke and Wheeler (1915, 1922) reveals an interesting fact that there exists considerable difference in the composition of the skeleton of various forms belonging to the same class. According to their work, the Brachiopods fall into two distinct groups; the shells of one consisting mainly of calcium carbonate with little organic matter, while the shells of the other group are formed mainly of calcium phosphate with much organic matter. The first group is represented by species of *Terebratula*, *Crania*, *Waldheimia*, and others, while the second group comprises *Lingula*, *Discinisca*, and *Glottidia*. The two groups are physiologically quite dissimilar, the chemical reactions involved in building the shells being of two different orders. Such a distinction, said Clarke, "ought to be significant to biologists and it is for them to determine what it means." Unfortunately, the biologists know very little about the reactions involved in building of shells and the significance of the difference just described is not understood.

Evidence that difference in the chemical composition of animals can be correlated with their habitat, and possibly with the temperature of the water in which they live, is found in another paper of Clarke and Kamm[12] dealing with the analyses of Echinoderm shells. Different species of starfishes show, according to this paper, a progressive enrich-

[10] Clarke, F. W. *Data of Geochemistry*. 1924. Washington.
[11] Lohmann, H. Intern. Rev. Ges. Hydrol. **1**: 309–323. 1908.
[12] Clarke, F. W., and Kamm, R. M. Proc. Nat. Acad. Sci. **3**: 401. 1917.

ment in magnesia following an increase in the temperature of their habitat. In the specimens from high latitudes or from deep water the proportion of magnesium carbonate ranges from 7 to 10 percent, while those from tropical waters contain from 11 to over 14 percent. We have at present no explanation to offer for the existence of such differences. These examples show very plainly that even within one taxonomic group the organisms differ from each other not only morphologically but also in the chemical composition of their bodies.

The cycle of silicon and the accumulation of this element by diatoms, radiolaria, and siliceous sponges is another oceanographical problem which attracted a great deal of attention. The rôle of the diatoms in the life of the ocean is well known to everybody acquainted with oceanographical problems. However, the question concerning the source of silicon, which is used by diatoms for building their tests remains unsolved. Murray has expressed a view that the amount of silicon found in solution in the sea water is insufficient to supply the demands of the diatoms and that the latter obtain this element by splitting the clay particles suspended in water. Later on (Murray and Irvine[13]), he was able to show experimentally that *Navicula* can live in water containing no silicon in solution, but only in suspension. These findings were corroborated by Vernadsky[14] who observed the formation of aluminum hydrates in the culture of *Nitzchia* grown together with the unidentified bacteria in a medium which contained silicon only in a form of suspended clay particles. It is known that the minerals, like mica, epidote, nephelene and others, transform into kaolin without changing their kaolin nucleus which has the following composition—$H_2Al_2Si_2O_8H_2O$. The kaolin nucleus is a very stable chemical compound which withstands heating up to 1000°C., but can be split by treatment with concentrated H_2SO_4 at 100°C. Yet it is apparently decomposed by the action of the organisms. The question is still open whether this is due to the activity of the diatoms or should be attributed to the bacteria that were grown in the diatom cultures.

We may briefly mention other organisms which are accumulators of various elements. It is a well known fact that iodine, which occurs in the sea in minute amounts, is accumulated by algae, gorgonacea, and sponges. In the latter it is found in the form of an albuminoid ($C_{56}H_{87}I\ N_{10}S_2O_2$). The amount of iodine in these organisms varies

[13] Murray, J., and Irvine, R. Proc. R. Soc. Edinb. **18**: 245. 1891.

[14] Vernadsky, W. Comptes. Rend. Acad. Sci., Paris, 450–452. 1922. Rev. Gen. d. Sc. Pures et Appliques, **34**: 42. 1923.

from 1.7 percent of dry substance (*Gorgonia acerosa*) to 7.8 in *Gorgonia clavellina.* Small amounts of iodine were observed in various molluscs and fishes. The physiological significance of this element in the metabolism of these forms is unknown.

The presence of copper in the bodies of marine invertebrates has been an object of numerous investigations. It is well known that copper enters into the composition of a respiratory pigment, haemocyanin, which in several forms (lobster, shrimps, crawfish and others) plays the rôle of haemoglobin. Copper was found also in a Coelenterate, *Anthea cereus* (2.35 mg. per 100 gr. wet weight); in Echinoderms, *Stichopus regalis,* (2.83 mg.), *Asterias rubens,* (2.45 mg.); in various molluscs, and in sardines, herring and salmon.

In the lamellibranchs that can accumulate copper in considerable amounts the metal occurs not as a protein compound but in a simpler form. It has been known for many years that in certain sections of the Atlantic coast, and around the British Isles, the oysters become green. The green pigment was associated with an increase in their copper content. It was thought that the pigment might be haemocyanin or at least similar to haemocyanin in chemical composition. Recent investigations by Galtsoff and Whipple[15] have shown that the green pigment of oysters is not haemocyanin or copper proteinate of any kind. It passes through a collodion membrane which holds back congo red and is not precipitated by sodium sulphate. Although its chemical nature remains undetermined, it has been found that the pigment exists in a highly dissociated state and is of a small molecular size.

The amount of copper accumulated by oysters is very variable. According to the determinations of Galtsoff and Whipple the copper content in normal oysters from Cape Cod varies from 0.16 to 0.24 mg. per oyster or from 8.21 to 13.77 mg. per 100 grams of dry weight. The amount of copper concentrated in green oysters from Long Island Sound varied from 1.24 to 5.12 mg. per oyster or from 121.71 to 271.91 mg. per 100 grams of dry weight. On the average there was about 2.5 mg. of pure copper in every green oyster. Knowing the copper content of green oysters and the extent of oyster beds affected by greening, it is possible to estimate the amount of copper which oysters withdraw annually from the water. There are at least 10,000 acres of oyster bottoms in Long Island Sound which produce green oysters. Assuming that oysters become green in one year, and that there are one

[15] Galtsoff, P. S., and Whipple, D. V. Bull. Bur. Fisheries, **46**: 489–508. 1931.

thousand bushels to each acre of ground, and that three hundred oysters make up one bushel, we arrive at the conclusion that the oysters of Long Island Sound deposit in their bodies about 7.5 metric tons of pure copper annually.

Space does not permit us to discuss the accumulation and possible rôle of strontium, found in the Radiolaria; barium, which was discovered as crystals of barium sulphate in the protoplasm of *Xenophyophora;* vanadium, discovered in the blood of Ascidians in which it apparently plays a rôle in the respiratory exchange of gases; and other elements (Zn, Mn, K, S, Fe, P, Al, etc.) which are accumulated by various forms.

After the death of the organism the accumulated material is deposited on the bottom and enters into new reactions resulting in the formation of various minerals found in the sedimentary rocks. Here the field of biology ends and we enter into realm of geology and mineralogy. Although the boundary line is indistinct, and the processes of accumulation of elements in living matter and their further rôle in the formation of minerals on the bottom of the sea are but the different phases of one cycle, we shall not trespass in this field, foreign to biologists, but return to the living organisms and consider how their lives may be affected by slight changes in the chemical composition of the sea water. This field of research scarcely has been touched by scientific investigations and our knowledge is therefore very limited. Interesting progress along this line was made, however, by recent work on oysters.

These molluscs inhabit the inshore waters where the environment is subject to periodical changes caused by the tides. Due to the discharge of river waters the salinity of the inshore area fluctuates quite widely. Consequently, the organisms living in this environment must adapt themselves to considerable fluctuations in osmotic pressure and to changes in the chemical composition of the water concurrent with the different stages of tide. It has been found by Prytherch[16] that the copper content of the water in Long Island Sound fluctuates between 0.1 part per million at high water and about 0.5 part per million at low tide. The increase in copper at low tide is due to the discharge of fresh water by the rivers. On the other hand, it has been observed in laboratory experiments that copper salts have a peculiar effect on oyster larvae, inducing their attachment to the substratum and initiating their metamorphosis. Under experimental conditions

[16] Prytherch, H. F. Science, **73**: 429–431. 1931.

the full grown larvae responded to copper treatment very readily and with great precision. By employing this method it was possible for the first time to obtain a complete photographic record of their behavior during setting and metamorphosis. That the peculiar effect was due to copper, but not to other elements which are brought in by rivers, was corroborated by numerous experiments with various salts of Fe, Pb, Zn, Mn, St, Ba, Al, Ni, Co, which gave no positive results. The anions are apparently not involved in this reaction because different copper salts (carbonates, sulphates and chlorides) had exactly the same effect.

The results of the laboratory experiments were corroborated by field observation. Prytherch observed the intensity of setting of oyster larvae by counting at brief intervals the number of larvae attached to a plate that had been placed in the bay. The intensity of setting increases with the increase in copper content of the water, the latter reaching its maximum at low tide. The two curves run parallel and are undoubtedly significant. These observations explain the peculiarity in the distribution of the natural oyster beds which occur mainly in the mouths of rivers. Apparently the river water, having a higher copper content, supplies the necessary stimulus that initiates the "setting" reaction of the full grown oyster larvae. The result is that the best setting areas are found on bottoms affected by fresh water. We are, however, ignorant as to the biochemical reaction involved in this phenomenon. It is extremely interesting that the organism reacts in a very distinct manner to slight fluctuations in the content of this metal, ranging only from 0.1 to 0.5 part per million. Greater concentrations of copper ions are distinctly injurious to the larvae causing the disintegration of their tissues and death. We are dealing here with an extremely well adjusted and sensitive mechanism which responds to slight changes in the environment.

The fluctuation in the concentration of other elements due to tidal changes may also have a pronounced effect on the activity of the organism. Hopkins, working in the Gulf of Mexico, has noticed considerable fluctuations in the potassium salts. Also in his work on the chemical sensitivity of the oyster[17] he found that the potassium ion has greater stimulating power in comparison with other metals. It is quite probable that fluctuations in the chemical composition of the environment may have a profound effect on all marine forms, and that they greatly influence their feeding, growth, and propagation.

[17] Hopkins A. E. Journ. Exp. Zool. **61**: 13–29. 1932.